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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/781,355	02/18/2004	Shin Sugawara	81872.0056	9247

26021 7590 01/25/2008

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EXAMINER	
HALL, ASHA J	

ART UNIT	PAPER NUMBER
1795	

MAIL DATE	DELIVERY MODE
01/25/2008	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 10/781,355	Applicant(s) SUGAWARA ET AL.	
	Examiner Asha Hall	Art Unit 1795	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 11 November 2007.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-21 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 1-21 is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☒ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.

5) ☐ Notice of Informal Patent Application

6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 102

1. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

2. Claims 1-3 are rejected under 35 U.S.C. 102(b) as being anticipated by Bartlett (4,514,580).

With regard to claim 1, Bartlett discloses a photoelectric conversion device comprising as shown in Figure 2:

- a substrate (4) serving as a lower electrode (col.1; lines: 43-46);
- first conductivity-type crystalline semiconductor particles (10) deposited on the substrate (col.4; lines: 1-3) ;
- second conductivity-type semiconductor layers (14) formed on the crystalline semiconductor particles (col. 4; lines: 7-10);
- an insulator layer (12) formed among the crystalline semiconductor particles (col.4; lines: 6-8);
- an upper electrode layer formed on the second conductivity-type semiconductor layers (col. 4; lines: 11-14),
- wherein the second conductivity-type semiconductor layers (14) each have a smaller thickness (0.2 μm) at an equator/outline of each of the crystalline

semiconductor particles (10) than at a zenith/top portion of the particle (col. 3; lines: 50-51)

In regard to claims 2 and 3, Bartlett discloses the photoelectric conversion device (Figure 2) as applied to claim 1 above, and further discloses that the first conductivity-type crystalline semiconductor (10) as a particle size of ~ 300 μm and the thickness of the n-type/second conductivity-type semiconductor (14) layers on the crystalline semiconductor particles at the equator/outline is 0.2 μm of that at the zenith/top portion (col. 3; lines: 50-51 & col.4; lines: 1-3). The n-type/second conductivity-type semiconductor semiconductor layer (14) is less than 70 and 40% of the zenith/top portion of the semiconductor particle (10).

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 4 is rejected under 35 U.S.C. 103(a) as being unpatentable over Bartlett (4,514,580) in view of Stanberry (4,322,571).

With respect to claims 4, Bartlett discloses the photoelectric conversion device (Figure 2) as applied to claim 1 above, but fails to disclose the crystalline semiconductor particles each have an indentation toward the interior thereof at a surface below the equator.

Stanbery discloses a photoelectric conversion device (col. 1; lines: 13-31) (Figure 2), and teaches that a textured surface/indentations/V-shaped ridges, (72) (col.14; lines: 37-38 and Figure 8D & 8E) so as to optimize both the light collection and current generation efficiencies (col.4; lines: 57-59). It would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate semiconductor particles with surface V-shaped ridges/ textured surface as taught by Stanbery to the photoelectric device of Bartlett in order to optimize both the light collection and current generation efficiencies.

5. Claims 5 is rejected under 35 U.S.C. 103(a) as being unpatentable over Bartlett (4,514,580) in view of Nakata (WO99/10935).

With respect to claims 5, Bartlett discloses the photoelectric conversion device (Figure 2) as applied to claim 1 above, but fails to disclose the crystalline semiconductor particles have rough surfaces.

Nakata discloses the photoelectric spherical semiconductor device (Figure 11 & col. 1; lines: 6-17) and further discloses irregularities/rough edges of the core particle (1) as shown in Fig. 11, with an elevation difference of 1 micrometer similar to the situation with spherical solar cell that has been sandblasted (col.16; lines: 12-17). Nakata teaches that a large proportion of the sphere surface is a p-n junction that generates a photovoltage, wherein a large portion of the light reaches the sphere surface (with elevation differences) wherein the light is scattered, absorbed, and converted to electricity (col.9; lines: 44-51) . It would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate semiconductor particles with surface

irregularity as taught by Nakata to the photoelectric device of Bartlett in order to have the light scattered, absorbed and converted to electricity.

6. Claims 4 and 5 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bartlett (4,514,580) in view of Sugawara et al. (US 2002/0162585).

With respect to claim 4, Bartlett discloses the photoelectric conversion device (Figure 2) as applied to claim 1 above, but fails to disclose the crystalline semiconductor particles each have an indentation toward the interior thereof at a surface below the equator.

Sugawara et al. ('585) discloses a photoelectric conversion device with semiconductor spherical particles (5) (paragraph 101) as shown in Figure 3, and further discloses pyramidal projections (5a) as shown in Figure 11 as having an indentation toward the interior thereof at a surface below the equator/outline (paragraph 76). Sugawara et al. teaches that when the pyramidal projection is formed the light that has entered the projection is refracted and direction to the crystalline semiconductor particles so as to contribute to power generation (paragraph 65). It would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate semiconductor particles with indentation toward the interior as taught by Sugawara et al. ('585) to the photoelectric conversion device of Bartlett in order to contributed to power generation.

In regard to claim 5, Bartlett discloses the photoelectric conversion device (Figure 2) according to claim 1, but fails to disclose wherein the crystalline semiconductor particles have a rough surface.

Sugawara et al. ('585) discloses a photoelectric conversion device with semiconductor spherical particles (5) (paragraph 101) as shown in Figure 3, and further discloses that the surface of the crystalline semiconductor particles are rough. Sugawara et al. ('585) teaches that by roughing the surfaces (5a) then the light incident on the crystalline semiconductor particles (5) is allowed to easily enter inside the crystalline semiconductor particles (5) and light reflected at the surface (5a) of the crystalline semiconductor particles (5) is scattered and directed to adjacent crystalline semiconductor particles (5) so that the conversion efficiency improves (paragraph 122). It would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate semiconductor spheres with rough surfaces as taught by Sugawara et al. ('585) to the photoelectric conversion device of Bartlett in order to improve the conversion efficiency.

7. Claims 6-8, 10, and 11 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bartlett (US 4,514,580) in view of Stanbery (US 4,322,571) and Arthur et al. (US 5,672,214).

With respect to claim 6, Bartlett discloses the photoelectric conversion device (Figure 2) comprising:

- a substrate (4) serving as a lower electrode (col.1; lines: 43-46);
- first conductivity-type crystalline semiconductor particles (10) deposited on the substrate (col.4; lines: 1-3) ;
- second conductivity-type semiconductor layers (14) formed on the crystalline semiconductor particles (col. 4; lines: 7-10);

- an insulator layer (12) formed among the crystalline semiconductor particles (col.4; lines: 6-8);
- an upper electrode layer formed on the second conductivity-type semiconductor layers (14) (col. 4; lines: 11-14),

However, Bartlett fails to disclose wherein the second conductivity-type semiconductor layers include an impurity element with a concentration decreasing with proximity to the crystalline semiconductor particles, wherein the impurity element comprises one element selected from the group consisting of oxygen, nitrogen, carbon, and hydrogen.

Stanbery discloses a photoelectric conversion device (col. 1; lines: 13-31) (Figure 2), and the n-type/second conductivity type semiconductor layer (64, 65) has higher impurity addition(increased concentration) (col.2; lines: 62-64) concentration at the surface region which provides the cells with a low resistance and excellent ohmic contact properties immediately adjacent to the electrodes (col. 1; lines: 16-28 & col.13; lines: 26-29). It would have been obvious to one of ordinary skill in the art at the time of the invention to have a higher impurity concentration at the surface of the n-type/second conductivity type as taught by Stanbery to the photoelectric device of modified Bartlett in order to provide the cells with a low resistance and excellent ohmic contact properties immediately adjacent to the electrodes.

Bartlett in view of Stanbery fails to disclose wherein the impurity element comprises of one element selected from the group consisting of oxygen, nitrogen, carbon, and hydrogen. However, Arthur et al. discloses a solar cell comprises of semiconductor particles (12) (abstract) and further discloses that the particles can be

made from high resistivity semiconductor silicon that is undoped or doped with p-type electron acceptor impurities by electrically activating dissolved oxygen in the silicon to change the silicon to n-type (col. 7; lines: 1-12). It would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate an impurity element such as oxygen to the semiconductor particles as taught by Arthur et al. to the modified photovoltaic conversion device of Bartlett in order to change the silicon semiconductor particles into n-type conductivity type.

With respect to claim 7, Bartlett discloses the photoelectric conversion device as applied to claim 6 above, but fails to disclose wherein the second conductivity-type semiconductor layers each have a thickness of not less than 5 nm and not more than 500nm.

Stanbery discloses a photoelectric conversion device (col. 1; lines: 13-31) (Figure 2), and the shallow junction depth of n-type/second conductivity type semiconductor layer (65) as shown in Figure 8F with a shallow diffusion layer thickness of 300nm to permit optimization and the improvement in the minority carrier lifetime (col. 15; lines: 36-50). It would have been obvious to one of ordinary skill in the art at the time of the invention to have a thickness of 300nm of the n-type/second conductivity type as taught by Stanbery to the photoelectric device of modified Bartlett in order to optimize and improve the minority carrier lifetime.

In regard to claim 8, Bartlett discloses the photoelectric conversion device (Figure 2) as applied to claim 6 above, but fails to disclose wherein a region of each of

the second conductivity-type semiconductor layers where the concentration of the impurity element is lowest comprises an intrinsic semiconductor.

Stanbery discloses a photoelectric conversion device (col. 1; lines: 13-31) (Figure 2). Stanbery discloses a lower surface concentration of impurity atoms in the n-type second conductivity-type semiconductor with a concentration profile (42) as shown in Figure 5, and further teaches that a shallow junction permits more current to be generated per unit of absorbed incident radiation (col.10; lines: 55-64). In this case, the n-type /second conductivity type semiconductor layer with lower surface concentration of impurity atoms behaves as an intrinsic semiconductor (i.e. electrical properties that are of an ideal crystal). It would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate the second conductivity-type semiconductor layers with a lower impurity at the surface as taught by Stanbery to the device of Bartlett in order to permit more current to be generated per unit of absorbed incident radiation.

In regard to claim 10, Bartlett discloses the photoelectric conversion device (Figure 2) as applied to claim 6 above, wherein the substrate (6) comprises aluminum (col. 3; lines: 67-68).

With respect to claim 11, Bartlett discloses a method of manufacturing the photoelectric conversion device comprising as shown in Figure 1:

- depositing first conductivity-type crystalline semiconductor particles on a substrate (4) (col.4; lines: 1-3) serving as a lower electrode (col.1; lines: 43-46);

- forming a second conductivity-type semiconductor layers (14) formed on the crystalline semiconductor particles (col. 4; lines: 7-10);
- forming an insulator layer (12) formed among the crystalline semiconductor particles (col.4; lines: 6-8;) and
- forming an upper electrode layer formed on the second conductivity-type semiconductor layers (14) (col. 4; lines: 11-14).

However, Bartlett fails to disclose so that at least one element selected from the group consisting of p-type or n-type impurities, oxygen, nitrogen, carbon and hydrogen is included in the semiconductor layers with a concentration gradient increasing with thickness.

Stanbery discloses a photoelectric conversion device (col. 1; lines: 13-31) (Figure 2) and further discloses p-type or n-type impurity (64, 65) has higher impurity addition (an increased concentration) (col.2; lines: 62-64) concentration at the surface region which provides the cells with a low resistance and excellent ohmic contact properties immediately adjacent to the electrodes (col. 1; lines: 16-28 & col.13; lines: 26-29). It would have been obvious to one of ordinary skill in the art at the time of the invention to have a higher impurity concentration at the surface of the n-type/second conductivity type as taught by Stanbery to the photoelectric device of modified Bartlett in order to provide the cells with a low resistance and excellent ohmic contact properties immediately adjacent to the electrodes.

Bartlett in view of Stanbery fails to disclose wherein the impurity element comprises of one element selected from the group consisting of oxygen, nitrogen,

carbon, and hydrogen. However, Arthur et al. discloses a solar cell comprises of semiconductor particles (12) (abstract) and further discloses that the particles can be made from high resistivity semiconductor silicon that is undoped or doped with p-type electron acceptor impurities by electrically activating dissolved oxygen in the silicon to change the silicon to n-type (col. 7; lines: 1-12). It would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate an impurity element such as oxygen to the semiconductor particles as taught by Arthur et al. to the modified photovoltaic conversion device of Bartlett in order to change the silicon semiconductor particles into n-type conductivity type.

8. Claims 12 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bartlett (4,514,580) and Stanbery (4,322,571) as applied to claim 11 above, and in further view of Nakata (6,294,822).

In regard to claims 12 and 13, Bartlett discloses the method of manufacturing a photoelectric conversion device (Figure 1) as applied to claim 11 above, and discloses that the particulate silicon undergoes the removal of the semi-conductor material by way of etching with a nitric and hydrofluoric acid solution prior to the spreading of the particulate onto the substrate (col.3; lines: 10-16). However, Bartlett fails to disclose an aluminum coating and the step of removing a part of the second conductivity-type/n-type semiconductor layers that adheres to the substrate after the formation of the second conductivity-type/n-type semiconductor layers.

Nakata discloses the photoelectric spherical semiconductor device (Figure 11 & col. 1; lines: 6-17) and further discloses electrodes which contact aluminum layer (22)

and the n-type/second conductive semiconductive layer (25) as shown in Figure 15, with circular openings (the n-type conductive surface was removed, since there is circular openings) which reach the surface of the aluminum layer (22) such that the n-type/second conductive semiconductive layer (25) are formed at two positions which are symmetric with respect to the center of the core to have the electrodes contact the aluminum layer (Figure 15 & col.15; lines: 29-39). It would have been obvious to one of ordinary skill in the art at the time of the invention to remove/expose the n-type/second conductive semiconductive layer (25) a taught by Nakata to the photoelectric device of Bartlett in order to have the electrodes contact the aluminum layer.

9. Claims 9 and 14-18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bartlett (4,514,580) and Stanbery (4,322,571) as applied to claim 6 above, and in further view of Nakata (6,294,822).

With respect to claim 9, Bartlett discloses the photoelectric conversion device (Figure 1) as applied to claim 6 above, but fails to disclose wherein an oxide layer or a nitride layer is formed between each of the crystalline semiconductor particles and the second conductivity-type semiconductor layers.

Nakata discloses the photoelectric spherical semiconductor device (Figure 11 & col. 1; lines: 6-17) and further discloses an oxide layer such as silicon dioxide, passivation film (9) as shown in Figure 7 formed over the entire surface of the spherical body (col.8; lines: 56-67). Nakata also teaches that the passivation film (9) reduces the recombination velocity of a minority of carriers and the proportion of photo-generated carriers, which contribute to the photoelectric conversion is increased (col.8; lines: 56-

67). It would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate an oxide layer/silicon dioxide layer (9) as taught by Nakata to the photoelectric device of Bartlett in order to increase the photoelectric conversion.

In regard to claims 14-16, Bartlett discloses the photoelectric conversion device (Figure 2) as applied to claim 6 above, and fails to discloses that the thickness of the second conductivity-type semiconductor layers on the semiconductor particles each have a smaller thickness at or below an equator of each of the semiconductor particles than at the zenith region thereof, and the thickness of each of the second conductivity type semiconductor layer on the crystalline semiconductor particles at or below the equator is 70% and 40% or less of that at the zenith.

Nakata discloses the photoelectric spherical semiconductor device (Figure 11 & col. 1; lines: 6-17) and further discloses that the p-type/first conductivity-type crystalline semiconductor (4) thickness is 10 μm (col. 7; lines: 59-62) and the thickness of the n-type/second conductivity-type semiconductor (6a) thickness at the equator/outline is 0.3-0.5 μm of that at the zenith/top portion (col. 8; lines: 45-52), which is 3% of thickness of the p-type/first conductivity-type crystalline semiconductor. Nakata teaches that an approximately sphere p-n junction is formed at the interface and is necessary for generation of photovoltage (col. 8; lines: 50-55). It would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate semiconductor particles with a n-type/second conductivity type semiconductor layer that is 3% of the p-type/first conductivity-type crystalline semiconductor (4) thickness as taught by Nakata to the photoelectric conversion device of modified Bartlett in order to generate a photovoltage.

With respect to claims 17 and 18, Bartlett discloses the photoelectric conversion device (Figure 2) as applied to claim 6 above, but fails to disclose the crystalline semiconductor particles each have an indentation toward the interior thereof at a surface below the equator.

Nakata discloses the photoelectric spherical semiconductor device (Figure 11 & col. 1; lines: 6-17) and further discloses irregularities/rough edges of the core particle (1) as shown in Fig. 11, with an elevation difference of 1 micrometer similar to the situation with spherical solar cell that has been sandblasted (col.16; lines: 12-17). Nakata teaches that a large proportion of the sphere surface is a p-n junction that generates a photovoltage, wherein a large portion of the light reaches the sphere surface directly or reflected light is scattered, absorbed, and converted to electricity (col.9; lines:44-51) . It would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate semiconductor particles with surface irregularity as taught by Nakata to the photoelectric device of Bartlett in order to generate electricity.

Stanbery discloses a photoelectric conversion device (col. 1; lines: 13-31) (Figure 2), and teaches that a textured surface, indentations toward the interior/ V-shaped ridges, (72) (col.14; lines: 37-38 and Figure 8D & 8E) so as to optimize both the light collection and current generation efficiencies (col.4; lines: 57-59). It would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate semiconductor particles with surface V-shaped ridges/ textured surface as taught by Stanbery to the photoelectric device of Bartlett in order to optimize both the light collection and current generation efficiencies.

10. Claims 6-16, 20, and 21 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bartlett (4,514,580) in view of Sugawara et al. (US 2002/0023674) and Arthur et al. (US 5,672,214).

With respect to claim 6, Bartlett discloses the photoelectric conversion device (Figure 2) comprising:

- a substrate (4) serving as a lower electrode (col.1; lines: 43-46);
- first conductivity-type crystalline semiconductor particles (10) deposited on the substrate (col.4; lines: 1-3) ;
- second conductivity-type semiconductor layers (14) formed on the crystalline semiconductor particles (col. 4; lines: 7-10);
- an insulator layer (12) formed among the crystalline semiconductor particles (col.4; lines: 6-8);
- an upper electrode layer formed on the second conductivity-type semiconductor layers (14) (col. 4; lines: 11-14),

However, Bartlett fails to disclose wherein the second conductivity-type semiconductor layers include an impurity element with a concentration decreasing with proximity to the crystalline semiconductor particles.

Sugawara et al. ('674) discloses a photoelectric conversion device with semiconductor spherical particles (3) (paragraph 103) as shown in Figure 1, and the n-type/second conductivity type semiconductor layer (4) that has two layers each of which has an impurity addition concentration that differs from the other such that the impurity

addition concentration in the lower layer of the second conductivity type semiconductor layer (4) is lower (decreasing) than that in the upper layer of the second conductivity type semiconductive layer (paragraph 47). Sugawara et al. ('674) further teaches that the upper layer of the second conductivity type semiconductive layer with higher impurity addition concentration/decreasing towards the lower layers can reduce the series resistance and prevent the conversion efficiency from lowering (paragraph 48). It would have been obvious to one of ordinary skill in the art at the time of the invention to add an impurity element to the second conductivity type with decreasing concentration as taught by Sugawara et al. ('674) to the photoelectric device of modified Bartlett in order to reduce the series resistance and prevent the conversion efficiency from lowering.

Bartlett in view of Sugawara ('674) fails to disclose wherein the impurity element comprises of one element selected from the group consisting of oxygen, nitrogen, carbon, and hydrogen. However, Arthur et al. discloses a solar cell comprises of semiconductor particles (12) (abstract) and further discloses that the particles can be made from high resistivity semiconductor silicon that is undoped or doped with p-type electron acceptor impurities by electrically activating dissolved oxygen in the silicon to change the silicon to n-type (col. 7; lines: 1-12). It would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate an impurity element such as oxygen to the semiconductor particles as taught by Arthur et al. to the modified photovoltaic conversion device of Bartlett in order to change the silicon semiconductor particles into n-type conductivity type.

With respect to claim 7, Bartlett discloses the photoelectric conversion device as applied to claim 6 above, but fails to disclose wherein the second conductivity-type semiconductor layers each have a thickness of not less than 5 nm and not more than 500nm.

Sugawara et al. ('674) discloses a photoelectric conversion device with semiconductor spherical particles (3) (paragraph 103) as shown in Figure 1, and further teaches that the second conductivity type semiconductive layer (4) is from 50-300nm (paragraph 80), because it is undesirable to make the thickness less than 50 nm because in such cases, the covering performance deteriorates and leakage due to direct contact of the semiconductor particles with transparent conductive film occurs, thereby deteriorating the properties (paragraph 80). It would have been obvious to one of ordinary skill in the art at the time of the invention to set the second conductivity type semiconductive layer thickness from 50-300 nm as taught by Sugawara et al. ('674) to the photoelectric conversion device of modified Bartlett in order to avoid poor covering performance and leakage thereby deteriorating the properties.

In regard to claim 8, Bartlett discloses the photoelectric conversion device (Figure 2) as applied to claim 6 above, but fails to disclose wherein a region of each of the second conductivity-type semiconductor layers where the concentration of the impurity element is lowest comprises an intrinsic semiconductor.

Sugawara et al. ('674) discloses a photoelectric conversion device with semiconductor spherical particles (3) (paragraph 103) as shown in Figure 1, and further disclose that the second conductivity-type semiconductor layers (4) has a lower impurity

addition concentration in the lower layer/region wherein the leakage current is prevented from occurring (intrinsic semiconductor i.e. electrical properties that are of an ideal crystal) then this device can achieve conversion efficiency higher than that of known photoelectric conversion device (paragraph 49). It would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate the second conductivity-type semiconductor layers with a lower impurity addition concentration in the lower layer/region as taught by Sugawara et al. ('674) to the device of Bartlett in order to prevent leakage current thereby achieving a higher conversion efficiency.

With respect to claim 9, Bartlett discloses the conversion device (Figure 2) applied to claim 6 above, wherein an oxide layer or a nitride layer is formed between each of the crystalline semiconductor particles and the second conductivity-type semiconductor layers (col.3; lines: 43-45).

In regard to claim 10, Bartlett discloses the photoelectric conversion device (Figure 2) as applied to claim 6 above, wherein the substrate (6) comprises aluminum (col. 3; lines: 67-68).

With respect to claim 11, Bartlett discloses a method of manufacturing the photoelectric conversion device comprising as shown in Figure 1:

- depositing first conductivity-type crystalline semiconductor particles on a substrate (4) (col.4; lines: 1-3) serving as a lower electrode (col.1; lines: 43-46);
- forming a second conductivity-type semiconductor layers (14) formed on the crystalline semiconductor particles (col. 4; lines: 7-10);

- forming an insulator layer (12) formed among the crystalline semiconductor particles (col.4; lines: 6-8;) and
- forming an upper electrode layer formed on the second conductivity-type semiconductor layers (14) (col. 4; lines: 11-14).

However, Bartlett fails to disclose so that at least one element selected from the group consisting of oxygen, nitrogen, carbon and hydrogen is included in the semiconductor layers with a concentration gradient increasing with thickness.

Sugawara et al. ('674) discloses a photoelectric conversion device with semiconductor spherical particles (3) (paragraph 103) as shown in Figure 1, and the n-type/second conductivity type semiconductor layer (4) with an impurity addition concentration in two layers (upper and lower) and that the impurity addition concentration in the lower layer of the n-type/second conductivity type semiconductor layer (4) is lower (decreasing) than that in the upper layer of the n-type/second conductivity type semiconductive layer (paragraph 47). Sugawara et al. ('674) further teaches that the upper layer of the n-type/second conductivity type semiconductive layer with higher impurity addition concentration/decreasing towards the lower layers can reduce the series resistance and prevent the conversion efficiency from lowering (paragraph 48). It would have been obvious to one of ordinary skill in the art at the time of the invention to add an impurity element to the second conductivity type with decreasing concentration as taught by Sugawara et al. ('674) to the photoelectric device of modified Bartlett in order to reduce the series resistance and prevent the conversion efficiency from lowering.

Bartlett in view of Sugawara ('674) fails to disclose wherein the impurity element comprises of one element selected from the group consisting of oxygen, nitrogen, carbon, and hydrogen. However, Arthur et al. discloses a solar cell comprises of semiconductor particles (12) (abstract) and further discloses that the particles can be made from high resistivity semiconductor silicon that is undoped or doped with p-type electron acceptor impurities by electrically activating dissolved oxygen in the silicon to change the silicon to n-type (col. 7; lines: 1-12). It would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate an impurity element such as oxygen to the semiconductor particles as taught by Arthur et al. to the modified photovoltaic conversion device of Bartlett in order to change the silicon semiconductor particles into n-type conductivity type.

In regard to claims 12 and 13, Bartlett discloses the method of manufacturing a photoelectric conversion device (Figure 1) as applied to claim 11 above, and discloses that the particulate silicon undergoes the removal of the semi-conductor material by way of etching with a nitric and hydrofluoric acid solution prior to the spreading of the particulate onto the substrate (col.3; lines: 10-16). However, Bartlett fails to disclose an aluminum coating, and steps of removing a part of the second conductivity-type semiconductor layers that adheres to the substrate after the formation of the second conductivity-type semiconductor layers.

Sugawara et al. ('674) discloses a photoelectric conversion device with semiconductor spherical particles (3) (paragraph 103) as shown in Figure 1, and further disclose prior to forming the insulator layer (102) among the crystalline semiconductor

particles, the step of removing a part of the n-type/second conductivity-type semiconductor layers (110b) that adheres to the substrate after the formation of the n-type/second conductivity-type semiconductor layers (110b) (paragraph 17). Sugawara et al. ('674) teaches that portions are removed so that the p-type cores (110a) are contacted with the lower aluminum foil/substrate (113) in forming a metal connector electrode (paragraph 16 and 17). It would have been obvious to one of ordinary skill in the art at the time of the invention to apply the method of removing a part of the second conductivity-type/n-type semiconductor layers as taught by Sugawara et al. ('674) to the photoelectric method of Bartlett in order to have the p-type cores to contact the aluminum foil thereby forming a metal in contact with the p-type semiconductor core.

In regard to claims 14-16, Bartlett discloses the photoelectric conversion device (Figure 2) as applied to claim 6 above, and further discloses that the first conductivity-type crystalline semiconductor as a particle size of ~ 300 μm and the thickness of the second conductivity-type semiconductor (14) layers on the crystalline semiconductor particles at the equator/outline is 0.2 μm of that at the zenith/top portion, which is 0.1% of thickness of the first conductivity-type crystalline semiconductor (radius ~ 150μm) (col. 3; lines: 50-51 & col.4; lines: 1-3).

With respect to claim 20, Bartlett discloses a method of manufacturing the photoelectric conversion device comprising as shown in Figure 1:

- a first conductivity-type crystalline semiconductor particles on a substrate (4) (col.4; lines: 1-3) serving as a lower/first electrode (col.1; lines: 43-46);

- a first conductivity-type crystalline semiconductor particles/curved surface (4) (col.4; lines: 1-3)
- a second conductivity-type semiconductor layers (14) formed on the crystalline semiconductor particles/curve surface (col. 4; lines: 7-10);
- a second electrode layer formed on the second conductivity-type semiconductor layers (14) (col. 4; lines: 11-14).

However, Bartlett fails to disclose so that at least one element selected from the group consisting of oxygen, nitrogen, carbon and hydrogen, wherein the impurity element has a lower concentration with proximity to the first conductivity type semiconductor region than with proximity to the second electrode.

Sugawara et al. ('674) discloses a photoelectric conversion device with semiconductor spherical particles (3) (paragraph 103) as shown in Figure 1, and the second conductivity type semiconductor layer (4) with an impurity addition concentration in two layers (upper and lower) such that the impurity addition concentration in the lower layer of the second conductivity type semiconductor layer (4) is lower (decreasing) than that in the upper layer of the second conductivity type semiconductive layer – the concentration is lower towards the first semiconductor type (paragraph 47) – region/particle than in the upper layer that is in contact with the electrode (paragraph 44). Sugawara et al. ('674) further teaches that the upper layer of the n-type/second conductivity type semiconductive layer with higher impurity addition concentration/decreasing towards the lower layers can reduce the series resistance and prevent the conversion efficiency from lowering (paragraph 48). It would have been

obvious to one of ordinary skill in the art at the time of the invention to add an impurity element to the second conductivity type with decreasing concentration as taught by Sugawara et al. ('674) to the photoelectric device of modified Bartlett in order to reduce the series resistance and prevent the conversion efficiency from lowering.

Bartlett in view of Sugawara ('674) fails to disclose wherein the impurity element comprises of one element selected from the group consisting of oxygen, nitrogen, carbon, and hydrogen. However, Arthur et al. discloses a solar cell comprises of semiconductor particles (12) (abstract) and further discloses that the particles can be made from high resistivity semiconductor silicon that is undoped or doped with p-type electron acceptor impurities by electrically activating dissolved oxygen in the silicon to change the silicon to n-type (col. 7; lines: 1-12). It would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate an impurity element such as oxygen to the semiconductor particles as taught by Arthur et al. to the modified photovoltaic conversion device of Bartlett in order to change the silicon semiconductor particles into n-type conductivity type.

In regard to claim 21, Bartlett discloses the photoelectric conversion device according to claim 20 above, but fails to disclose wherein the impurity element has concentrations of $5X10^{15}$ to $5x10^{19}$ atoms/cm^3 on the lower side of the second conductivity type semiconductor region, and concentrations of $1X10^{18}$ to $5x10^{21}$ atoms/cm^3 on the upper side of the second conductivity type semiconductor region.

Sugawara et al. ('674) discloses a photoelectric conversion device with semiconductor spherical particles (3) (paragraph 103) as shown in Figure 1, and the

second conductivity type semiconductor layer (4) with an impurity addition concentration may be high such as 10^{16}-10^{21}atoms/cm^3 (paragraph 108) wherein Sugawara further discloses that the second conductivity type is divided into two layers (upper and lower) such that the impurity addition concentration in the lower layer of the second conductivity type semiconductor layer (4) is lower (decreasing) than that in the upper layer of the second conductivity type semiconductive layer – the concentration is lower towards the first semiconductor type (paragraph 47) –region/particle than in the upper layer that is in contact with the electrode (paragraph 44). Sugawara et al. ('674) further teaches that the upper layer of the n-type/second conductivity type semiconductive layer with higher impurity addition concentration/decreasing towards the lower layers can reduce the series resistance and prevent the conversion efficiency from lowering (paragraph 48). It would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate impurity additions of 10^{16}-10^{21}atoms/cm^3 to thesecond conductivity type as taught by Sugawara et al. ('674) to the photoelectric device of modified Bartlett in order to reduce the series resistance and prevent the conversion efficiency from lowering.

11. Claims 17 and 18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bartlett (4,514,580), Sugawara et al. (US 2002/0023674), and Arthur et al. (US 5, 672,214) as applied to claim 14 above, and in further view of Sugawara et al. (US 2002/0162585).

With respect to claim 17, Bartlett discloses the photoelectric conversion device

(Figure 2) as applied to claim 14 above, but fails to disclose the crystalline semiconductor particles each have an indentation toward the interior thereof at a surface below the equator.

Sugawara et al. ('585) discloses a photoelectric conversion device with semiconductor spherical particles (5) (paragraph 101) as shown in Figure 3, and further discloses pyramidal projections (5a) as shown in Figure 11 as having an indentation toward the interior thereof at a surface below the equator/outline (paragraph 76). Sugawara et al. ('585) teaches that when the pyramidal projection is formed the light that has entered the projection is refracted and direction to the crystalline semiconductor particles so as to contribute to power generation (paragraph 65). It would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate semiconductor particles with indentation toward the interior as taught by Sugawara et al. ('585) to the photoelectric conversion device of Bartlett in order to contributed to power generation.

In regard to claim 18, Bartlett discloses the photoelectric conversion device (Figure 2) as applied to claim 14 above, but fails to disclose wherein the crystalline semiconductor particles have rough surface.

Sugawara et al. ('585) discloses a photoelectric conversion device with semiconductor spherical particles (5) (paragraph 101) as shown in Figure 3, and further discloses that the surface of the crystalline semiconductor particles are rough. Sugawara et al. teaches that by roughing the surfaces (5a) then the light incident on the crystalline semiconductor particles (5) is allowed to easily enter inside the crystalline

semiconductor particles (5) and light reflected at the surface (5a) of the crystalline semiconductor particles (5) is scattered and directed to adjacent crystalline semiconductor particles (5) so that the conversion efficiency improves (paragraph 122). It would have been obvious to one of ordinary skill in the art at the time of the invention to incorporate semiconductor spheres with rough surfaces as taught by Sugawara et al. ('585) to the photoelectric conversion device of Bartlett in order to improve the conversion efficiency.

12. Claims 19 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bartlett (4,514,580), Sugawara et al. (US 2002/0023674), and Arthur et al. (US 5,672,214) as applied to claim 6 above, and in further view of Stanbery (US 4,322,571).

With respect to claim 19, Bartlett discloses a photoelectric conversion device according to claim 6, but fails to disclose wherein the second conductivity type semiconductor layer further comprise a second impurity element selected from the group consisting of B, P, Al, As, and Sb, the second impurity having a concentration decreasing with proximity to the crystalline semiconductor particles.

Sugawara et al. ('674) discloses a photoelectric conversion device with semiconductor spherical particles (3) (paragraph 103) as shown in Figure 1, and the n-type/second conductivity type semiconductor layer (4) with an impurity addition concentration in two layers (upper and lower) and that the impurity addition concentration in the lower layer of the n-type/second conductivity type semiconductor layer (4) is lower (decreasing) than that in the upper layer of the n-type/second conductivity type semiconductive layer (paragraph 47). Sugawara et al. ('674) further

teaches that the upper layer of the n-type/second conductivity type semiconductive layer with higher impurity addition concentration/decreasing towards the lower layers can reduce the series resistance and prevent the conversion efficiency from lowering (paragraph 48). It would have been obvious to one of ordinary skill in the art at the time of the invention to add an impurity element to the second conductivity type with decreasing concentration as taught by Sugawara et al. ('674) to the photoelectric device of modified Bartlett in order to reduce the series resistance and prevent the conversion efficiency from lowering.

Bartlett in view of Sugawara et al. ('674) fails to disclose a semiconductor layer further comprise a second impurity element selected from the group consisting of B, P, Al, As, and Sb. Stanbery discloses a photoelectric conversion device (col. 1; lines: 13-31) (Figure 2) and further discloses p-type or n-type impurity (64, 65) has high impurity addition (e.g. phosphorous, boron, arsenic, antimony, etc...) (col.2; lines: 62-64) concentration at the surface region which provides the cells with a low resistance and excellent ohmic contact properties immediately adjacent to the electrodes (col. 1; lines: 16-28 & col.13; lines: 26-29). It would have been obvious to one of ordinary skill in the art at the time of the invention to have a higher impurity concentration at the surface of the n-type/second conductivity type as taught by Stanbery to the photoelectric device of modified Bartlett in order to provide the cells with a low resistance and excellent ohmic contact properties immediately adjacent to the electrodes.

Response to Arguments

Claim Rejections - 35 USC § 102

1. In regard to claims 1 and all the dependant claims, the Applicant argues that Bartlett cannot anticipate or render claim 1 obvious, because Bartlett fails to teach or suggest " the second conductivity type semiconductor layers each have a smaller thickness at or below an equator of each of the crystalline semiconductor particles than at a zenith thereof".

The Examiner respectfully disagrees. The insulator layer 12 of Bartlett acts as a barrier for the lower half of the first semiconductor type particle10 creating a gradient region of the exterior of the first type semiconductor particle 10 such that the second semiconductor layer 14 has a thickness less below half of the particle than that of the top of the first semiconductor particle 10.

Claim Rejections - 35 USC § 103

2. With respect to claim 4, the Applicant argues that claim 4 depends from claim 1 and as such includes all the limitations of claim 1, and therefore, cannot be rendered obvious over Bartlett for the same reasons discussed above. The Applicant further argues that Stanbery cannot remedy the defect of Bartlett and is not relied upon by the Office for such. Instead, the Office cites Stanbery for teaching a photoelectric conversion device and a textured surface/indentations/V-shaped ridges so as to optimize the light collection and current generation efficiencies.

The Examiner respectfully disagrees. Stanbery discloses a photoelectric conversion device (col. 1; lines: 13-31) (Figure 2), and teaches that a textured surface/indentations/V-shaped ridges, (72) (col.14; lines: 37-38 and Figure 8D & 8E) so as to optimize both the light collection and current generation efficiencies (col.4; lines: 57-59).

3. In regard to claim 5, the Applicant argues that since claim 5 depends from claim 1 and as such includes all the limitations of claim 1, and therefore, cannot be rendered obvious over Bartlett for the same reasons discussed above. Nakata (WO99/10935) cannot remedy the defect of Bartlett and is not relied upon by the Office for such.

The Examiner respectfully disagrees. Nakata discloses the photoelectric spherical semiconductor device (Figure 11 & col. 1; lines: 6-17) and further discloses irregularities/rough edges of the core particle (1) as shown in Fig. 11, with an elevation difference of 1 micrometer similar to the situation with spherical solar cell that has been sandblasted (col.16; lines: 12-17). Nakata teaches that a large proportion of the sphere surface is a p-n junction that generates a photovoltage, wherein a large portion of the light reaches the sphere surface (with elevation differences) wherein the light is scattered, absorbed, and converted to electricity (col.9; lines: 44-51) .

4. With respect to claims 4 and 5, the Applicant argues that claims 4 and 5 depend from claim 1 and as such include all the limitations of claim 1, and therefore, cannot be rendered obvious over Bartlett for the same reasons discussed above. Sugawara

(USPPN. 2002/0162585) cannot remedy the defect of Bartlett and is not relied upon by the Office for such.

The Examiner respectfully disagrees. Sugawara et al. ('585) discloses a photoelectric conversion device with semiconductor spherical particles (5) (paragraph 101) as shown in Figure 3, and further discloses pyramidal projections (5a) as shown in Figure 11 as having an indentation toward the interior thereof at a surface below the equator/outline (paragraph 76). Sugawara et al. teaches that when the pyramidal projection is formed the light that has entered the projection is refracted and direction to the crystalline semiconductor particles so as to contribute to power generation (paragraph 65).

As for claim 5, Sugawara et al. ('585) discloses a photoelectric conversion device with semiconductor spherical particles (5) (paragraph 101) as shown in Figure 3, and further discloses that the surface of the crystalline semiconductor particles are rough. Sugawara et al. ('585) teaches that by roughing the surfaces (5a) then the light incident on the crystalline semiconductor particles (5) is allowed to easily enter inside the crystalline semiconductor particles (5) and light reflected at the surface (5a) of the crystalline semiconductor particles (5) is scattered and directed to adjacent crystalline semiconductor particles (5) so that the conversion efficiency improves (paragraph 122).

5. All arguments directed towards amended claims 6, 11, and all its dependants, require new grounds of rejection as presented above.

Conclusion

6. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Asha Hall whose telephone number is 571-272-9812. The examiner can normally be reached on Monday-Thursday 8:30-7:00PM EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Alexa Neckel can be reached on 571-272-1446. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

AJH

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Alexa Neckel

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